Advances in Hollow Thread Bar
Micro Pile
Installation Techniques,
Equipment, Materials, Testing
and Monitoring

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There are two different kinds of continuous, external threaded Hollow Bars available, mostly in standard drill rod length of 3.0 Meters, (10 feet).

One with an R-Thread or Rope Thread and the other one with the Titan Thread.
Titan Thread shoulder 45+ degree

R-Thread shoulder 20- degree
This presentation is based on the Hollow TITAN Bar System with the Titan Thread which we found to have certain quality and technical advantages over our R-Thread Bars, specifically for difficult and permanent installations using the IBO® method.
What is IBO®?

IBO = Grout Injection Boring
Developed in 1985 by the company Ischebeck in Germany and later Con-Tech Systems in Canada and in the USA.

Grout Injection Bored Hollow Bar Micro Piles are gaining increasing acceptance by engineers and the industry.

Quality materials and equipment as well as a professional installation technique has to be applied to achieve a quality end product and also the desired ground improvement.
Installation Techniques and Equipment

Rotary or rotary-percussion drill with top hammer, sized for the various sizes of bars and bits. Rotation speed shall be up to 160 RPM, left turning for hollow bars up to 52 mm with left hand threads. For all other larger bars with right hand threads use hydraulic drills with right turn motors.

Drill rigs meeting these parameters are provided by: TEI, Euro Drill, Klemm, Krupp, Huette, Casagrande, Davy Drill, etc.
Typical TEI rotary-percussion drill with top hammer and flushing head mounted on an excavator.
Limited access or low head room installations

Techno Drill

Euro Hammer on a Davy Drill
Grout Mixer and Grout Pump

• Typical equipment which meets these parameters is manufactured by:
  - Obermann, MAT, Hany, Colcrete, Chem-Grout
For best results, use a high speed - high shear mixer with separate holding tank and water/cement dosing system to assure:

- continuous grouting, independent from mixing.

- There should be preferably two mixers, one for the thinner flushing grout and one for the final grout.

When rock is encountered, water flushing is required.
To assure high pressure ability during flushing or grouting, a piston or double plunger pump with minimum 60 l/minute capacity and 80 bar (1000 psi) pressure capability is recommended for cleaning out grout or dirt blockages in hoses or hollow bars, to assure uninterrupted grout flushing.
MAT mixer, one holding tank and double plunger pump
High speed high shear mixer with two water tanks and two mixers. One for the thinner flushing grout and one for the final grout. Also a double plunger pump.
Obermann VS 110

Mixer with water dosing and cement weighing scales
The use of an automatic logging system for measuring, recording and documenting of grout volume and pressure is also recommended.
Installation Techniques

Drilling, Flushing and Grouting
Flushing head on a Klemm 804.

The holder is bolted to the hammer to prevent the housing from rotating.

The hollow Titan bar is screwed directly into the flushing head.
Threading on drill bit
The drill shall be equipped with a hydraulic clamp to prevent un-threading of couplers below ground. (Very important when using R-Thread Bars).
Start pumping and make sure grout will exit drill bit.
flushing out drill cuttings
Outflow of final grout, notice different colors.
The Structure of Hollow Bar Micro Piles
The hollow bar, used as both drill rod and grout conduit, is left in the ground as reinforcing steel to transmit compression, tension, and lateral forces. Hollow bars have a larger section modulus than solid bars which increases their bending capacity. With the continuous tremi-grout injection, 100% grout cover and therefore excellent corrosion protection is accomplished, similar to reinforcing steel in concrete.
The rotation and jetting of the cement grout into the surrounding ground, stabilizes the borehole, consolidates the soil and increases its original shear strength in most soils.
Typical cross section of an exhumed IBO® Micro-Pile

1- Hollow Bar
2- Final Grout W/C 0.45
3- Flushing grout W/C 0.7 Soil Cement mix
4- Ground improvement
Materials

Since the hollow bars are used as drill rods and subjected to high torque forces, the steel shall be of a fine grain and ductile quality. The thread type deformations shall develop bond to the grout, the same as with deformations on concrete reinforcing bars.
TITAN Hollow Bars range in size from 30 to 130 mm (1 ¼” to 5”) diameter with ultimate tensile loads up to 7940 kN, (1785 Kips), 892 tons
Important Requirement:

The thread shall be designed to transfer loads through the couplings (every 10 feet) without excessive slippage inside couplers and shall comply to requirements for mechanical splices of reinforcing bars.
Typical TITAN Bars meeting the requirements of reinforcing steel ASTM A615 specifications for deformation requirement and bond development.
TITAN Drill bits

A: clay and sand bit
B: cross cut bit for gravel, hardened for sand stone and weathered rock
C: carbide cross cut bits for varies rocks
D: button bits for hard rock

 Titan Hollow Bar

CON-TECH SYSTEMS LTD.
Construction-Technology Systems
Grout ports in Drill Bits
Jets can be threaded into the bits to create higher pressure to enlarge pile diameter.
Full strength Couplers
Special bayonet coupler for special underwater installations

Couplers with centre stop and seals
Steel Centralizer to allow for grout passage
Spherical hex nuts,  
2 nuts for tension/compression piles,  
(bearing plate with top and bottom nut)
Testing

There is no difference between testing Hollow Bar Micro Piles and Standard Micro Piles
Typical tension test set up for a pile group
Typical compression tests
Monitoring

Hollow Bar Micro-Piles with Vibrating Wire strain gauges inside
Installing strain gauges on a fiberglass rod pushed into a hollow bar.
Titan Bar 73/53 with 6" VWSG-E Strain
Gauge cf RST VWA-220-3.937 S/N VC1300

Predicted strain from COSMO FEM model

Initial Loading Cycle

Calibration loading response chart

Titan Hollow Bar
This test plot shows the loads in the three gauges. Only the test load L-1 and all locked-in residual loads are shown after relaxing the load to 5 Kips and zero load.
Some Interesting Current Projects
The following projects are examples where this product contributed in large to their success, not only economically but also technically.
Seismic upgrading and Underpinning of the Capitol State Building in Salt Lake City, Utah
over 3000 Hollow Bar Micro Piles were installed
Difficult installation, under low head room

Titan Hollow Bar

49
Limited access
Drilling pile groups

51
Pile groups for underpinning existing foundations
Testing pile groups in tension with a single jack
forming pile caps
Seismic Upgrading of a Bank Building in Berkeley California
Micro Pile Foundations for Wind Power Turbines
Placing of Reinforcing Steel and Sleeves

GTMO WINDTURBINE
ROCK ANCHOR BOX
INSTALLATION WITH
5” PIPE FROM BOX DOWN

10/19/2004
0713

Titan Hollow Bar
Placing of Concrete Pile Cap
Drilling Hollow Bars Through Pile Cap
Post-Tensioning and Testing

2004/11/19

GTMO WINDTURBINE TESTING ANCHORS AT WT #1 SITE
Placing of Tower
Two Devil Slide Projects for Caltrans, Pacific Coastal Highway, PCH-1
40 Miles south of San Francisco

- Emergency slide stabilization as per Chapter 6 of the FHWA Implementation Manual,
  Design of Micro Piles for slope stabilization

- South Tunnel Portal,
  New Retaining Wall Support
The project
No. 1

Emergency Slide Stabilization with Micro Piles as per chapter 6 of the FHWA Micro Pile Implementation Manual
Titan Hollow Bar
Failing, existing shotcrete slope
Installing new IBO-Titan Anchors
Titan Hollow Bar

Drilling from a cage

69

CON-TECH SYSTEMS LTD.
Construction-Technology Systems
Drilling battered micro piles
Vertical and battered micro piles
Forming of Pile Cap
Finished emergency Slide Repair
Using Hollow Bar Micro Piles, for slope stabilization, Caltrans could re-open the Pacific Coastal Highway two months ahead of schedule.
No 2.

South Tunnel Portal
Retaining Wall Support and slope stabilization
Over 140 straight and battered Micro Piles to support the new retaining Wall and to stabilize the slope below.
Vertical and battered Micro Piles

Titan
Hollow Bar

CON-TECH
SYSTEMS LTD.
Construction-Technology Systems
Grout Injection Boring
Trench to collect flushing grout
Random compression tests of production piles
80
Exposed excellent ground improvement
Forming of retaining wall
Piles are overlapping into wall by 1.0 m
Road is re-aligned
Titan Hollow Bar

Ready for TBM, (Tunnel Boring Machine)

86
California coast line at Devil Slide